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JC13 Rec'd PCT/PTO 27 MAR 2002

FORM PTO-1390) (REV. 9-2001) U S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE **TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371**		ATTORNEY'S DOCKET NUMBER **367.41482X00 filed March 27, 2002** U S APPLICATION NO (If known, see 37 CFR 1 5) 10/089145
INTERNATIONAL APPLICATION NO **PCT/IB99/01668**	INTERNATIONAL FILING DATE **September 19, 1999**	PRIORITY DATE CLAIMED **September 29, 1999**
TITLE OF INVENTION **SPREAD SPECTRUM COMMUNICATION SYSTEM**		
APPLICANT(S) FOR DO/EO/US **HOLMA, HARRI**		

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☐ This express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. ☒ The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2)))
   a. ☐ is transmitted hereto (required only if not communicated by the International Bureau).
   b. ☒ has been communicated by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office(RO/US)
6. ☒ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. ☒ is attached hereto.
   b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
7. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. ☐ are attached hereto (required only if not communicated by the International Bureau).
   b. ☐ have been communicated by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☐ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ An English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3 31 is included.
13. ☒ A FIRST preliminary amendment.
14. ☐ A SECOND or SUBSEQUENT preliminary amendment.
15. ☒ A substitute specification.
16. ☒ A change of power of attorney and/or address letter.
17. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
18. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. ☒ Other items or information: **Figs. 1-6, Credit Card Payment Form, PCT Request Form, International Preliminary Examination Report, International Publication Number WO 01/24396**

10/088914 JC13 Rec'd PCT/PTO 21 MAR 2002

U.S. APPLICATION NO. (If known, see 37 CFR 1.5) 10/088914	INTERNATIONAL APPLICATION NO. PCT/IB99/01668	ATTORNEY'S DOCKET NUMBER 367.41482X00

21. The following fees are submitted

BASIC NATIONAL FEE (37 CFR 1.492(a) (1) - (5)):

☐ Neither international preliminary examination fee (37 CFR 1 482) nor international search fee (37 CFR 1 445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO **$1040.00**

☒ International preliminary examination fee (37 CFR 1 482) not paid to USPTO but International Search Report prepared by the EPO or JPO **$890.00**

☐ International preliminary examination fee (37 CFR 1 482) not paid to USPTO but international search fee (37 CFR 1 445(a)(2)) paid to USPTO **$740.00**

☐ International preliminary examination fee (37 CFR 1 482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) **$710.00**

☐ International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) **$100.00**

				CALCULATIONS	PTO USE ONLY
ENTER APPROPRIATE BASIC FEE AMOUNT =				**$890.00**	
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).				$	
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	$	
Total Claims	20 - 20 =	0	x $18.00	$	
Independent Claims	3 - 3 =	0	x $84.00	$	
MULTIPLE DEPENDENT CLAIMS(S) (if applicable) 280			+ $280.00	$	
TOTAL OF ABOVE CALCULATIONS =				**$890.00**	
☐ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by ½. +				$	
SUBTOTAL =				**$890.00**	
Processing fee of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)).				$	
TOTAL NATIONAL FEE =				**$890.00**	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				$	
TOTAL FEES ENCLOSED =				**$890.00**	
				Amount to be refunded:	$
				charged:	$

a. ☐ A check in the amount of $______ to cover the fees is enclosed

b. ☐ Please charge my Deposit Account No. **01-2135** in the amount of $______ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposition Account No **01-2135**. A duplicate copy of this sheet is enclosed.

d. ☒ Fees are to be charged to a credit card **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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SIGNATURE

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367.41482X00

IN THE UNITED STATES RECEIVING OFFICE

Applicant:	:	Harri HOLMA
Interml. Appln. No.	:	PCT/IB99/01668
Interml. Filing Date	:	29 September 1999
Title:	:	SPREAD SPECTRUM COMMUNICATION SYSTEM

PRELIMINARY AMENDMENT

Assistant Commissioner of Patents
Washington, D.C. 20231

March 27, 2002

Sir:

Prior to examination, please amend the above-identified application as indicated below and consider the remarks which follow.

IN THE SPECIFICATION:

Please replace the original specification with the attached Substitute Specification. A marked-up copy of the original specification showing the amendments is attached. It is submitted that the amendments do not introduce new matter.

IN THE CLAIMS:

Please cancel claims 1-14 without prejudice or disclaimer and substitute new claims 15-34 as follows:

15. A method of estimating the spreading factor of data in a channel in a spread spectrum radio communication system comprising a transmitter and a receiver, wherein the transmitter transmits a data unit at one of a plurality of spreading factors over a data channel and transmits in parallel over a control channel a control unit comprising information for decoding the data unit,

the method comprising the steps of:

decoding an initial portion of the control unit;

decoding an initial portion of the data unit at an assumed one of the plurality of spreading factors; and

calculating the received power of the initial portions of the control unit and the data unit to make an estimate of the spreading factor used to transmit the data unit.

16. A method as in Claim 15, wherein data in the control unit and the data unit is interleaved over the duration of the respective units.

17. A method as in Claim 16, wherein the data unit comprises a single

frame.

18. A method as in Claim 16, wherein the data unit comprises a plurality of frames.

19. A method as in Claim 15, wherein the assumed spreading factor is the lowest of the plurality of spreading factors.

20. A method as in Claim 15, wherein the estimate is calculated by matching the relationship between the received powers of the control unit and the data unit with a member of a set of possible power relationships known *a priori*, wherein each member of the set corresponds to one of the spreading factors.

21. A method as in Claim 15, wherein, after having made the estimate, a remainder of the data unit is decoded using the estimate of the spreading code.

22. A method as in Claim 15, wherein the data unit comprises data relating to a plurality of user services.

23. A method of estimating the spreading factor of data in a channel in a

spread spectrum radio communication system comprising a transmitter and a receiver, wherein the transmitter transmits a data unit at one of a plurality of spreading factors over a data channel and transmits in parallel over a control channel a control unit comprising information for decoding the data unit,

the method comprising the steps of:

decoding an initial portion of the control unit;

decoding the whole of the data unit at an assumed one of the plurality of spreading factors; and

calculating the received power of the initial portions of the control unit and the data unit to make an estimate of the spreading factor used to transmit the data unit.

24. A spread spectrum radio communication system, comprising :

a transmitter which transmits a data unit at one of a plurality of spreading factors over a data channel and transmits in parallel over a control channel a control unit comprising information for decoding the data unit; and

a receiver comprising a decoder for decoding an initial portion of the control unit, a decoder for decoding an initial portion of the data unit at an assumed one of the plurality of spreading factors; and means for calculating the received power of

the initial portions of the control unit and the data unit to make an estimate of the spreading factor used to transmit the data unit.

25. A mobile station including a receiver as defined in Claim 22.

26. A method as in Claim 16, wherein the assumed spreading factor is the lowest of the plurality of spreading factors.

27. A method as in Claim 17, wherein the assumed spreading factor is the lowest of the plurality of spreading factors.

28. A method as in Claim 18, wherein the assumed spreading factor is the lowest of the plurality of spreading factors.

29. A method as in Claim 26, wherein the estimate is calculated by matching the relationship between the received powers of the control unit and the data unit with a member of a set of possible power relationships known *a priori,* wherein each member of the set corresponds to one of the spreading factors.

30. A method as in Claim 17, wherein the estimate is calculated by matching the relationship between the received powers of the control unit and the data unit with a member of a set of possible power relationships known *a priori,* wherein each member of the set corresponds to one of the spreading factors.

31. A method as in Claim 18, wherein the estimate is calculated by matching the relationship between the received powers of the control unit and the data unit with a member of a set of possible power relationships known *a priori,* wherein each member of the set corresponds to one of the spreading factors.

32. A method as in Claim 19, wherein the estimate is calculated by matching the relationship between the received powers of the control unit and the data unit with a member of a set of possible power relationships known *a priori,* wherein each member of the set corresponds to one of the spreading factors.

33. A method as in Claim 16, wherein data in the control unit and the data unit is interleaved over the duration of the respective units.

34. A method as in Claim 17, wherein the data unit comprises a single frame.

REMARKS

The claims have been amended prior to calculation of the filing fee to avoid multiple dependent claims and to improve the claims for examination.

To the extent necessary, applicants petition for an extension of time under 37 CFR §1.136. Please charge any shortage in the fees due in connection with the filing of this paper, including extension of time fees, to Deposit Account No. 01-2135 (367.41482X00) and please credit any excess fees to such deposit account.

Respectfully submitted,

ANTONELLI, TERRY, STOUT & KRAUS, LLP

for ~~Donald E. Stout~~ 22973
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10/089145
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Substitute Specification

SPREAD SPECTRUM COMMUNICATION SYSTEM

BACKGROUND OF THE INVENTION

Field of the Inventio

The present invention relates generally to a spread spectrum communication system, and more specifically, to spreading factor estimation in a spread spectrum communication system.

Description of the Prior Art

In a spread spectrum system, a modulation technique is used which spreads the information signal over a wide frequency band within the communication channel. The frequency band is much wider than the minimum bandwidth required to carry the information signal. For example, if the information signal is a voice signal, it may have a bandwidth of only a few kilohertz but, during transmission, it's energy could be spread so as to be transmitted over a channel 5 MHz wide. This is accomplished by modulating the information signal with a wideband encoding signal. The information signal is then recovered by remapping the received spread spectrum into its original bandwidth.

Spread spectrum systems can be multiple access communication systems. One type is a code division multiple access (CDMA) system. In a CDMA system, users of the system can simultaneously use the same wideband physical communication channel (for example, the same 5MHz part of the spectrum) with the signals between one group/pair of users being differentiated from that of another by a unique spreading code.

The present invention is a particularly applicable to a cellular system. A highly schematic cellular architecture is shown in Figure 1. The system comprises a plurality of macrocell base stations 10 (only an exemplary 10a, 10b, 10c being shown) providing service within a corresponding macrocell 12 (only an exemplary 12a, 12b, 12c being shown). The system also comprises a plurality of mobile stations 14 (only an exemplary 14a and 14b are shown in the macrocell 10a). Each base station 10 communicates with the mobile stations 14 on a CDMA channels at a frequency F1 and a bandwidth of 5 MHz, the communication channel (s) carried out between a base station 10 and a mobile station 14 in the service area thereof being defined by at least one unique spreading code.

SUMMARY OF THE INVENTION

The present invention is concerned with communications between a base station and a mobile station taking place over a multirate data channel having a corresponding control channel which is (i) transmitted in parallel with the data channel and which (ii) needs to be adequately decoded to extract control information in order to properly decode the data channel. This situation is illustrated in Fig. 1 in the downlink direction between the base station 10a and the mobile station 14a. The data channel is labelled DPDCH and the control channel is labelled DPCCH is labelled.

The present invention provides a method of estimating the spreading factor of data in a channel in a spread spectrum radio communication system comprising a transmitter and a receiver, wherein the transmitter transmits a data unit at one of a plurality of spreading factors over a data channel and transmits in parallel over a control channel a control unit comprising information for decoding said data unit,

the method comprising the steps of:

decoding an initial portion of the control unit;

decoding an initial portion of the data unit at an assumed one of the plurality of spreading factors; and

calculating the received power of the initial portions of the control unit and the data unit to make an estimate of the spreading factor used to transmit the data unit. This situation is illustrated in Fig~~ure~~ 1 in the downlink direction between the base station 10a and the mobile station 14a. The data channel is labelled DPDCH and the control channel is labelled DPCCH is labelled.

The present invention also provides a method of estimating the spreading factor of data in a channel in a spread spectrum radio communication system comprising a transmitter and a receiver, wherein the transmitter transmits a data unit at one of a plurality of spreading factors over a data channel and transmits in parallel over a control channel a control unit comprising information for decoding the data unit,

the method comprising the steps of:

decoding an initial portion of the control unit;

decoding an initial portion of the data unit at an assumed one of the plurality of spreading factors; and

calculating the received power of the initial portions of the control unit and the data unit to make an estimate of the spreading factor used to transmit the data unit.

By estimating the correct spreading factor used to transmit the data unit based only on an initial portion of the control unit and the data unit, the data unit can thereafter be properly decoded. Provision for the buffering of a whole data unit need not be made. It is also an advantage that, for the control channel, the transmission power need not be so high nor coding so powerful, because the information for decoding the data unit is not the only indicator of the spreading factor used to transmit the data unit.

The data in the data unit and the control unit is preferably interleaved. The length of the data unit and the control unit corresponds to the interleaving interval. For example, when the data is interleaved over one system frame, the control unit and the data unit each occupy one system frame. Moreover, when data is interleaved over a number of frames, the control unit and the data unit occupy that number of frames. In this case, because the spreading factor is constant over an interleaving interval, when the second and subsequent frames of a data unit are transmitted their spreading factor is already known. In one embodiment, the ~~said~~ initial portion of the data unit can comprise one system frame.

Preferably, the lowest of the possible spreading factors is used to decode the initial portion of the data unit. By using this spreading factor, even if the data was actually transmitted with a higher spreading factor, the integrity of the data remains in tact even if it is poorly noise filtered.

The present invention is also a spread spectrum radio communication system, comprising a transmitter which transmits a data unit at one of a plurality of spreading factors over a data channel and transmits in parallel over a control channel a control unit comprising information for decoding the data unit, and a receiver comprising a decoder for decoding an initial portion of the control unit, a decoder for decoding an initial portion of the data unit at an assumed one of the plurality of spreading factors; and means for calculating the

received power of the initial portions of the control unit and the data unit to make an estimate of the spreading factor used to transmit the data unit.

The present invention can be applied to especially, but not exclusively, to W_CDMA uplink.

In the context of the present invention, the term 'estimating the spreading factor' is used. It will be appreciated by those skilled in the art that by determining the spread factor (essentially a layer 1) quantity, the bit rate of data coming from the layer is also, in effect, being determined, the bit rate being a straightforward and known function of the amount of repetition applied by the channel coding.

BRIEF DESCRIPTION OF THE DRAWINGS

Exemplary embodiments of the invention are hereinafter described with reference to the accompanying drawings, in which:

Fig. 1 shows a diagram of a cellular system useful for explaining the present invention;

Fig. 2 shows a diagram of a mobile station transmitter architecture;

Fig. 3 shows a diagram of a base station receiver architecture;

Fig. 4 shows the frame structure of the DPCCH and DPDCH from an air interface perspective;

Figs. 5(a-c) show the signal constellations for the receiver of Fig. 3 with the DPDCH channel transmitting at three different power levels/spreading factors; and

Fig. 6 shows the frames shown in Fig. 4 from a user service perspective.

B DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring back to Fig. 1, in order for the base stations 10 to communicate with the mobile stations or radiotelephones 14, that is to set up, release and maintain connections therebetween, a number of functions need to be achieved over the air in both the uplink and the downlink These functions are carried out by means of logical channels.

Generically, the basic functions to be carried out are (i) *synchronization*, where the mobile station locks onto the timing of a base station, enabling it to decode other channels; (ii) *broadcast*, where, for the purposes of initialization, the mobile station decodes system and cell specific information e.g. cell identities, spreading codes, access channel and neighboring cells lists; (iii) *random access*, where the mobile station can initiate a service request; (iv) *paging*, whereby an incoming service can be directed to the mobile station; (v) *dedicated channel control,* necessary for carrying signalling information such as handover measurements, service adaptation information, and power control information; (vi) *traffic*, necessary for carrying a wide variety of user-service data. Thus, generally logical channels exist corresponding to each of the functions (i) to (vi).

These basic functions can be mapped into physical channels, wherein the precise choice of how the logical channel are mapped into the physical channels will be highly system dependant.

In the system of the illustrated embodiment, the downlink comprises three common channels: a primary and a secondary common control physical channel (CCPCH), and a synchronisation channel (SCH) (function (i) above). The downlink also includes dedicated physical data channels (DPDCH) (function (vi) above) and physical control channel (DPCCH) (function (v)

above). The primary CCPCH incorporates the point to multipoint broadcast control channel (BCCH) (function (ii) above). The secondary CCPCH comprises a forward access channel (FACH) and a paging channel (PCH) (function (iv) above). The FACH is used for carrying control information to a mobile station when the network knows the location cell of the mobile station.

The uplink comprises one common channel, the random access channel (function (iii) above). The uplink also includes dedicated physical data channels (DPDCH) (function (vi) above) and physical control channel (DPCCH) (function (v) above).

When a mobile station, say 14a, is first powered up it initializes and registers with the network using the SCH to acquire synchronization to the strongest base station, which in this case is 14a. Once synchronization has occurred the mobile station 14a detects the CCPCH, reading the system and cell specific BCCH information. From the BCCH, the mobile station 14a acquires codes permitting it to make a call request with the network. After initialization, the mobile station enters idle mode and waits to be paged by an incoming service, for example, by an incoming call, or for the user to request a service, for example place an outgoing call.

Services for the user are provided using the previously mentioned DPDCH and the DPCCH. Each of these physical channel consists of 10ms frames, each frame comprising 15 slots. In one mode, services are provided with the frames operating in a mode hereinafter referred to as the multirate mode. In this mode, the PDCH carries the user-service data at a data rate which is constant within a single frame, but may vary from frame to frame. The DPCCH carries control information necessary to decode the DPDCH. Specifically, each frame of the DPCCH includes a transport format indication TFI which carries information indicating the data rate of the corresponding frame of the DPDCH. The DPCCH also carries power control symbols, pilot

symbols and service parameter information for the corresponding frame of the DPDCH. The DPCCH is transmitted at constant data rate.

Fig. 2 shows the transmitter 30 architecture of a mobile station for transmitting data on these two physical channels. The base station comprises a DPDCH baseband processor 32 for baseband processing data for transmission on the DPDCH, and a DPCCH baseband processor 34 for baseband processing data for transmission on the DPCCH. Each baseband processor 32, 34 is operable to provide the conventional baseband processing operations, including, for example, convolution coding, turbo coding, puncturing/repetition and interleaving.

The data from each baseband processor 32, 34 is fed to a spreading modulation element 36. Within the spreading modulation element 36, the data for the DPDCH is spread by PN code Cd in a spreading element 38 and scaled by a factor Ad in scaling element 40 to give a signal I, and the data for DPDCH is spread by PN code Cc in spreading element 42 and scaled in scaling unit 44 by a factor Ac to give a signal Q. The codes Cd and Cc are orthogonal variable spreading factor codes. The signals I, Q are then fed to a quadrature modulator (QPSK) 46 to produce a signal I + jQ. This signal is then spread again by a PN scrambling code Cscramb in spreading element 48 which is a complex user-specific scrambling code to give signal R. The codes Cd and Cc are for channelisation.

The multiplexed and spread signal R is then upconverted to the frequency F, power amplified and transmitted by RF section 50.

Fig. 3 shows the receiver 60 architecture for the receiver of the base station. The receiver 60 comprises an RF section 80 for demodulating the received signals into the I,Q parts. A power estimator unit provides an estimate of the power of I and Q and feeds this information to a baseband processing unit 65.

As described below in more detail below, the baseband processing unit of the receiver 60 is able to use the power estimates I and Q to calculate an estimate of the spreading factor/data rate.

The frame structure of the multirate mode is illustrated in Fig. 4. 5 exemplary 10ms frames are shown, the DPCCH frames are labelled 101 to 105, and the corresponding DPDCH frames are labelled 201 to 205.

If Fig. 4 is considered as a simple example of a uplink transmission, from the air interface (layer 1) perspective, the user data stream is transmitted on DPDCH as three data units. Data unit 1 is transmitted over frames 1 and 2 at the highest power, P1 (and hence lowest spreading factor); data unit 2 is transmitted over frames 3 and 4 at a lesser power, P2; and data unit 3 is transmitted over frame 5 only at the lowest power, P3 (and hence highest spreading factor). The data rate of the blocks is changed by changing the length of the spreading codes or using parallel spreading codes in the spreading modulation unit 36 or by puncturing/repetition in the DPDCH baseband processor 32. Because of the interleaving operation in the baseband processor 32, the user service data is interleaved over both frames 1 and 2 in block 1, over both frames 3 and 4 in block 2, and over only frame 5 in block 3. Similarly, the data stream in the DPCCH, notably the FCH, is interleaved over frames 1 and 2, frames 3 and 4, and frame 5, corresponding to the data units in the DPCCH. As explained above though, the transmission power on this channel is constant, P0.

The receiver 60 knows *a priori* the set of possible ratios of data channel receive power to control channel receive power. Expressed in other words, it may be thought that the receiver 60 knows the set of absolute transmission powers/spreading factors, because the channel attenuation of the data channel and the control channel is approximately the same, the corresponding received powers are related to the corresponding transmission

power by the same factor of proportionality. Hence, the set of possible ratios of data channel power to control channel power as transmitted are the same as the set possible of possible powers on reception.

Thus, in this way, the transmission power and hence the spreading factor can be estimated in principle. Figs. 5(a-c) show the signal constellations for received power is P3', P2' and P1', respectively. It will be appreciated that because the control and data channels are subjected to varying degrees of attenuation, the magnitude of the signal constellations vectors varies, but because the attenuation is approximately the same, their angles remain the same.

Referring again to Fig. 4, in order to estimate the relationship between the received power of the control channel and the data channel before the spreading factor used to transmit the data channel can be decoded from the control channel DPCCH, the data channel DPCDH signal is decoded assuming the lowest of the set of allowed spreading factors. With this assumption, the samples from the first 20 % or so of frame 1 of the data channel DPCDH are decoded and averaged to give a power estimate Pda. Over the same interval, the control channel DPCCH is also decoded at its known, fixed spreading factor. The samples decoded from each channel are squared and averaged to give an estimate Pca. The ratio Pda/Pca will correspond more closely to one of P3'/P0', P2'/P0' or P1'/P0' and hence yield an estimate of the corresponding spreading factor. Once an estimate of the spreading factor is so obtained, decoding of the data channel begins at the estimated spreading factor and hence little buffering is needed. In this way, both frames 1 and 2 are decoded. The process is then repeated for data unit 2, and subsequently for data unit 3.

It will be appreciated that as the number of frames in a data unit increases the advantage of not having to buffer the whole data unit to properly to decode the TFI becomes more and more significant.

Because communication between the base station 10a and the mobile station 14a takes place over a multirate data channel DPDCH having a corresponding control channel DPCCH which is transmitted in parallel and carries information about the data on the data channel, this channel architecture can be exploited advantageously in accordance with the described preferred embodiment of the invention to flexibly bundle a variety of user services into the data channel according to the priority of the services and the current data rate supportable by the data channel. For example, if there are four sets of user service data which need to be transmitted, say services 1 to 4 and, for convenience of explanation, the priority of the services is also in numerical order (whereby service 1 is the highest priority and service 4 is the lowest priority), then these services could be transmitted in accordance with the preferred embodiment of the invention as shown in ~~Figure~~ 6. In Figure 6, the same data units 1 to 3 of ~~Figure~~ 4 are considered from a user services perspective. In data unit 1, transmitted with the power P1, where the spreading factor is the lowest and hence the data rate the highest, all services 1 to 4 are being transmitted.. In data unit 2, which is at a lower power P1 and lower data rate, only higher priority services 1 and 2 are transmitted. In data unit 3, which is at the lowest power P2 and lowest data rate (highest spreading factor), only the highest priority service 1 is transmitted. Although for diagrammatic simplicity the services are shown in consecutive, separate time segments, in practice, each service is evenly interleaved over the respective data unit.

In other embodiments, the whole data unit can be decoded before estimation of the data rate/ spreading factor because this may lead to better estimation.

SPREAD SPECTRUM COMMUNICATION SYSTEM

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates generally to a spread spectrum communication system, and more specifically, to spreading factor estimation in a spread spectrum communication system.

Description of the Prior Art

In a spread spectrum system, a modulation technique is used which spreads the information signal over a wide frequency band within the communication channel. The frequency band is much wider than the minimum bandwidth required to carry the information signal. For example, if the information signal is a voice signal, it may have a bandwidth of only a few kilohertz but, during transmission, it's energy could be spread so as to be transmitted over a channel 5 MHz wide. This is accomplished by modulating the information signal with a wideband encoding signal. The information signal is then recovered by remapping the received spread spectrum into its original bandwidth.

Spread spectrum systems can be multiple access communication systems. One type is a code division multiple access (CDMA) system. In a CDMA system, users of the system can simultaneously use the same wideband physical communication channel (for example, the same 5MHz part of the spectrum) with the signals between one group/pair of users being differentiated from that of another by a unique spreading code.

The present invention is a particularly applicable to a cellular system. A highly schematic cellular architecture is shown in Fig~~ure~~.1. The system comprises a plurality of macrocell base stations 10 (only an exemplary 10a, 10b, 10c being shown) providing service within a corresponding macrocell 12 (only an

exemplary 12a, 12b, 12c being shown). The system also comprises a plurality of mobile stations 14 (only an exemplary 14a and 14b are shown in the macrocell 10a). Each base station 10 communicates with the mobile stations 14 on a CDMA channels at a frequency F1 and a bandwidth of 5 MHz, the communication channel (s) carried out between a base station 10 and a mobile station 14 in ~~its~~ the service area thereof being defined by at least one unique spreading code.

SUMMARY OF THE INVENTION

The present invention is concerned with [the situation where] communications between a base station and a mobile station ~~take~~ taking place over a multirate data channel having a corresponding control channel which is (i) transmitted in parallel with the data channel and which (ii) needs to be adequately decoded to extract control information in order to properly decode the data channel. This situation is illustrated in Fig~~ure~~.1 in the downlink direction between the base station 10a and the mobile station 14a. The data channel is labelled DPDCH and the control channel is labelled DPCCH is labelled.

~~According to one aspect~~ The present invention ~~may~~ provides a method of estimating the spreading factor of data in a channel in a spread spectrum radio communication system comprising a transmitter and a receiver, wherein the transmitter transmits a data unit at one of a plurality of spreading factors over a data channel and transmits in parallel over a control channel a control unit comprising information for decoding said data unit,

the method comprising the steps of:

decoding an initial portion of the control unit;

decoding an initial portion of the data unit at an assumed one of ~~said~~ the plurality of spreading factors; and

calculating the received power of the initial portions of the control unit and the data unit to make an estimate of the spreading factor used to transmit the data unit. This situation is illustrated in Fig~~ure~~.1 in the downlink direction between the base station 10a and the mobile station 14a. The data channel is labelled DPDCH and the control channel is labelled DPCCH is labelled.

~~According to one aspect~~ the present invention also ~~may~~ provides a method of estimating the spreading factor of data in a channel in a spread spectrum radio communication system comprising a transmitter and a receiver, wherein the transmitter transmits a data unit at one of a plurality of spreading factors over a data channel and transmits in parallel over a control channel a control unit comprising information for decoding the ~~said~~ data unit,

the method comprising the steps of:

decoding an initial portion of the control unit;

decoding an initial portion of the data unit at an assumed one of the ~~said~~ plurality of spreading factors; and

calculating the received power of the initial portions of the control unit and the data unit to make an estimate of the spreading factor used to transmit the data unit.

By estimating the correct spreading factor used to transmit the data unit based only on an initial portion of the control unit and the data unit, the data unit can thereafter be properly decoded. Provision for the buffering of a whole data unit need not be made. It is also an advantage that, for the control channel, the transmission power need not be so high nor coding so powerful,

because ~~said~~ the information for decoding the data unit is not the only indicator of the spreading factor used to transmit the data unit.

The data in the data unit and the control unit is preferably interleaved. The length of the data unit and the control unit corresponds to the interleaving interval. For example, when the data is interleaved over one system frame, the control unit and the data unit each occupy one system frame. Moreover, when data is interleaved over a number of frames, the control unit and the data unit occupy that number of frames. In this case, because the spreading factor is constant over an interleaving interval, when the second and subsequent frames of a data unit are transmitted their spreading factor is already known. In one embodiment, the ~~said~~ the initial portion of the data unit can comprise one system frame.

Preferably, the lowest of the possible spreading factors is used to decode the initial portion of the data unit. By using this spreading factor, even if the data was actually transmitted with a higher spreading factor, the integrity of the data remains in tact even if it is poorly noise filtered.

~~According to another aspect~~, The present invention ~~may provide~~ is also a spread spectrum radio communication system, comprising a transmitter which transmits a data unit at one of a plurality of spreading factors over a data channel and transmits in parallel over a control channel a control unit comprising information for decoding ~~said~~ the data unit, and a receiver comprising a decoder for decoding an initial portion of the control unit, a decoder for decoding an initial portion of the data unit at an assumed one of ~~said~~ the plurality of spreading factors; and means for calculating the received power of the initial portions of the control unit and the data unit to make an estimate of the spreading factor used to transmit the data unit.

The present invention can be applied to especially, but not exclusively, to W_CDMA uplink.

In the context of the present invention, the term 'estimating the spreading factor' is used. It will be appreciated by those skilled in the art that by determining the spread factor (essentially a layer 1) quantity, the bit rate of data coming from the layer is also, in effect, being determined, the bit rate being a straightforward and known function of the amount of repetition applied by the channel coding.

BRIEF DESCRIPTION OF THE DRAWINGS

Exemplary embodiments of the invention are hereinafter described with reference to the accompanying drawings, in which:

Fig~~ure~~.1 shows a diagram of a cellular system useful for explaining the present invention;

Fig~~ure~~.2 shows a diagram of a mobile station transmitter architecture;

Fig~~ure~~.3 shows a diagram of a base station receiver architecture;

Fig~~ure~~.4 shows the frame structure of the DPCCH and DPDCH from an air interface perspective;

Fig~~ures~~.5(a-c) show the signal constellations for the receiver of Fig~~ure~~.3 with the DPDCH channel transmitting at three different power levels/spreading factors; and

Fig~~ure~~.6 shows the frames shown in Fig~~ure~~.4 from a user service perspective.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring back to Fig~~ure~~.1, in order for the base stations 10 to communicate with the mobile stations or radiotelephones 14, that is to set up, release and maintain connections therebetween, a number of functions need to be achieved over the air in both the uplink and the downlink These functions are carried out by means of logical channels.

Generically, the basic functions to be carried out are (i) *synchroni~~s~~zation*, where the mobile station locks onto the timing of a base station, enabling it to decode other channels; (ii) *broadcast*, where, for the purposes of initiali~~s~~zation, the mobile station decodes system and cell specific information e.g. cell identities, spreading codes, access channel and neighbo~~u~~ring cells lists; (iii) *random access*, where the mobile station can initiate a service request; (iv) *paging*, whereby an incoming service can be directed to the mobile station; (v) *dedicated channel control,* necessary for carrying signalling information such as handover measurements, service adaptation information, and power control information; (vi) *traffic*, necessary for carrying a wide variety of user-service data. Thus, generally logical channels exist corresponding to each of the functions (i) to (vi).

These basic functions can be mapped into physical channels, wherein the precise choice of how the logical channel are mapped into the physical channels will be highly system dependant.

In the system of the illustrated embodiment, the downlink comprises three common channels: a primary and a secondary common control physical channel (CCPCH), and a synchronisation channel (SCH) (function (i) above). The downlink also includes dedicated physical data channels (DPDCH) (function (vi) above) and physical control channel (DPCCH) (function (v) above). The primary CCPCH incorporates the point to multipoint broadcast control channel (BCCH) (function (ii) above). The secondary CCPCH

comprises a forward access channel (FACH) and a paging channel (PCH) (function (iv) above). The FACH is used for carrying control information to a mobile station when the network knows the location cell of the mobile station.

The uplink comprises one common channel, the random access channel (function (iii) above). The uplink also includes dedicated physical data channels (DPDCH) (function (vi) above) and physical control channel (DPCCH) (function (v) above).

When a mobile station, say 14a, is first powered up it initialises and registers with the network using the SCH to acquire synchronisation to the strongest base station, which in this case is 14a. Once synchronisation has occurred the mobile station 14a detects the CCPCH, reading the system and cell specific BCCH information. From the BCCH, the mobile station 14a acquires codes permitting it to make a call request with the network. After initialisation, the mobile station enters idle mode and waits to be paged by an incoming service, for example, by an incoming call, or for the user to request a service, for example place an outgoing call.

Services for the user are provided using the previously mentioned DPDCH and the DPCCH. Each of these physical channel consists of 10ms frames, each frame comprising 15 slots. In one mode, services are provided with the frames operating in a mode hereinafter referred to as the multirate mode. In this mode, the PDCH carries the user-service data at a data rate which is constant within a single frame, but may vary from frame to frame. The DPCCH carries control information necessary to decode the DPDCH. Specifically, each frame of the DPCCH includes a transport format indication TFI which carries information indicating the data rate of the corresponding frame of the DPDCH. The DPCCH also carries power control symbols, pilot

symbols and service parameter information for the corresponding frame of the DPDCH.. The DPCCH is transmitted at constant data rate.

Fig~~ure~~. 2 shows the transmitter 30 architecture of a mobile station for transmitting data on these two physical channels. The base station comprises a DPDCH baseband processor 32 for baseband processing data for transmission on the DPDCH, and a DPCCH baseband processor 34 for baseband processing data for transmission on the DPCCH. Each baseband processor 32, 34 is operable to provide the conventional baseband processing operations, including, for example, convolution coding, turbo coding, puncturing/repetition and interleaving.

The data from each baseband processor 32, 34 is fed to a spreading modulation element 36. Within the spreading modulation element 36, the data for the DPDCH is spread by PN code Cd in a spreading element 38 and scaled by a factor Ad in scaling element 40 to give a signal I, and the data for DPDCH is spread by PN code Cc in spreading element 42 and scaled in scaling unit 44 by a factor Ac to give a signal Q. The codes Cd and Cc are orthogonal variable spreading factor codes. The signals I, Q are then fed to a quadrature modulator (QPSK) 46 to produce a signal I + jQ. This signal is then spread again by a PN scrambling code Cscramb in spreading element 48 which is a complex user-specific scrambling code to give signal R. The codes Cd and Cc are for channelisation.

The multiplexed and spread signal R is then upconverted to the frequency F, power amplified and transmitted by RF section 50.

Fig~~ure~~. 3 shows the receiver 60 architecture for the receiver of the base station.

The receiver 60 comprises an RF section 80 for demodulating the received signals into the I,Q parts. A power estimator unit provides an estimate of the power of I and Q and feeds this information to a baseband processing unit 65. As described below in more detail below, the baseband processing unit of the receiver 60 is able to use the power estimates I and Q to calculate an estimate of the spreading factor/data rate.

The frame structure of the multirate mode is illustrated in Fig~~ure~~.4. 5 exemplary 10ms frames are shown, the DPCCH frames are labelled 101 to 105, and the corresponding DPDCH frames are labelled 201 to 205.

If Fig~~ure~~.4 is considered as a simple example of a uplink transmission, from the air interface (layer 1) perspective, the user data stream is transmitted on DPDCH as three data units. Data unit 1 is transmitted over frames 1 and 2 at the highest power, P1 (and hence lowest spreading factor); data unit 2 is transmitted over frames 3 and 4 at a lesser power, P2; and data unit 3 is transmitted over frame 5 only at the lowest power, P3 (and hence highest spreading factor). The data rate of the blocks is changed by changing the length of the spreading codes or using parallel spreading codes in the spreading modulation unit 36 or by puncturing/repetition in the DPDCH baseband processor 32. Because of the interleaving operation in the baseband processor 32, the user service data is interleaved over both frames 1 and 2 in block 1, over both frames 3 and 4 in block 2, and over only frame 5 in block 3. Similarly, the data stream in the DPCCH, notably the FCH, is interleaved over frames 1 and 2, frames 3 and 4, and frame 5, corresponding to the data units in the DPCCH. As explained above though, the transmission power on this channel is constant, P0.

The receiver 60 knows *a priori* the set of possible ratios of data channel receive power to control channel receive power. Expressed in other words, it

may be thought that the receiver 60 knows the set of absolute transmission powers/spreading factors, because the channel attenuation of the data channel and the control channel is approximately the same, the corresponding received powers are related to the corresponding transmission power by the same factor of proportionality. Hence, the set of possible ratios of data channel power to control channel power as transmitted are the same as the set possible of possible powers on reception.

Thus, in this way, the transmission power and hence the spreading factor can be estimated in principle. Fig~~ure~~. 5(a-c) show~~s~~ the signal constellations for received power is P3', P2' and P1', respectively. It will be appreciated that because the control and data channels are subjected to varying degrees of attenuation, the magnitude of the signal constellations vectors varies, but because the attenuation is approximately the same, their angles remain the same.

Referring again to Fig~~ure~~ 4, in order to estimate the relationship between the received power of the control channel and the data channel before the spreading factor used to transmit the data channel can be decoded from the control channel DPCCH, the data channel DPCDH signal is decoded assuming the lowest of the set of allowed spreading factors. With this assumption, the samples from the first 20 % or so of frame 1 of the data channel DPCDH are decoded and averaged to give a power estimate Pda. Over the same interval, the control channel DPCCH is also decoded at its known, fixed spreading factor. The samples decoded from each channel are squared and averaged to give an estimate Pca. The ratio Pda/Pca will correspond more closely to one of P3'/P0', P2'/P0' or P1'/P0' and hence yield an estimate of the corresponding spreading factor. Once an estimate of the spreading factor is so obtained, decoding of the data channel begins at the estimated spreading factor and hence little buffering is needed. In this way,

both frames 1 and 2 are decoded. The process is then repeated for data unit 2, and subsequently for data unit 3.

It will be appreciated that as the number of frames in a data unit increases the advantage of not having to buffer the whole data unit to properly to decode the TFI becomes more and more significant.

Because communication between the base station 10a and the mobile station 14a takes place over a multirate data channel DPDCH having a corresponding control channel DPCCH which is transmitted in parallel and carries information about the data on the data channel, this channel architecture can be exploited advantageously in accordance with the described preferred embodiment of the invention to flexibly bundle a variety of user services into the data channel according to the priority of the services and the current data rate supportable by the data channel. For example, if there are four sets of user service data which need to be transmitted, say services 1 to 4 and, for convenience of explanation, the priority of the services is also in numerical order (whereby service 1 is the highest priority and service 4 is the lowest priority), then these services could be transmitted in accordance with the preferred embodiment of the invention as shown in Fig~~ure~~.6. In Fig~~ure~~.6, the same data units 1 to 3 of Fig~~ure~~.4 are considered from a user services perspective. In data unit 1, transmitted with the power P1, where the spreading factor is the lowest and hence the data rate the highest, all services 1 to 4 are being transmitted.. In data unit 2, which is at a lower power P1 and lower data rate, only higher priority services 1 and 2 are transmitted. In data unit 3, which is at the lowest power P2 and lowest data rate (highest spreading factor), only the highest priority service 1 is transmitted. Although for diagrammatic simplicity the services are shown in consecutive, separate time segments, in practice, each service is evenly interleaved over the respective data unit.

In other embodiments, the whole data unit can be decoded before estimation of the data rate/ spreading factor because this may lead to better estimation.

SPREAD SPECTRUM COMMUNICATION SYSTEM

The present invention relates generally to a spread spectrum communication system, and more specifically, to spreading factor estimation in a spread spectrum communication system.

In a spread spectrum system, a modulation technique is used which spreads the information signal over a wide frequency band within the communication channel. The frequency band is much wider than the minimum bandwidth required to carry the information signal. For example, if the information signal is a voice signal, it may have a bandwidth of only a few kilohertz but, during transmission, it's energy could be spread so as to be transmitted over a channel 5 MHz wide. This is accomplished by modulating the information signal with a wideband encoding signal. The information signal is then recovered by remapping the received spread spectrum into its original bandwidth.

Spread spectrum systems can be multiple access communication systems. One type is a code division multiple access (CDMA) system. In a CDMA system, users of the system can simultaneously use the same wideband physical communication channel (for example, the same 5MHz part of the spectrum) with the signals between one group/pair of users being differentiated from that of another by a unique spreading code.

The present invention is a particularly applicable to a cellular system. A highly schematic cellular architecture is shown in Figure 1. The system comprises a plurality of macrocell base stations 10 (only an exemplary 10a, 10b, 10c being shown) providing service within a corresponding macrocell 12 (only an

exemplary 12a, 12b, 12c being shown). The system also comprises a plurality of mobile stations 14 (only an exemplary 14a and 14b are shown in the macrocell 10a). Each base station 10 communicates with the mobile stations 14 on a CDMA channels at a frequency F1 and a bandwidth of 5 MHz, the communication channel (s) carried out between a base station 10 and a mobile station 14 in its service area being defined by at least one unique spreading code.

The present invention is concerned with the situation where communication between a base station and a mobile station take place over a multirate data channel having a corresponding control channel which is (i) transmitted in parallel with the data channel and which (ii) needs to be adequately decoded to extract control information in order to properly decode the data channel. This situation is illustrated in Figure 1 in the downlink direction between the base station 10a and the mobile station 14a. The data channel is labelled DPDCH and the control channel is labelled DPCCH is labelled.

According to one aspect the present invention may provide a method of estimating the spreading factor of data in a channel in a spread spectrum radio communication system comprising a transmitter and a receiver, wherein the transmitter transmits a data unit at one of a plurality of spreading factors over a data channel and transmits in parallel over a control channel a control unit comprising information for decoding said data unit,

the method comprising the steps of:

decoding an initial portion of the control unit;

decoding an initial portion of the data unit at an assumed one of said plurality of spreading factors; and

calculating the received power of the initial portions of the control unit and the data unit to make an estimate of the spreading factor used to transmit the data unit. This situation is illustrated in Figure 1 in the downlink direction between the base station 10a and the mobile station 14a. The data channel is labelled DPDCH and the control channel is labelled DPCCH is labelled.

According to one aspect the present invention may provide a method of estimating the spreading factor of data in a channel in a spread spectrum radio communication system comprising a transmitter and a receiver, wherein the transmitter transmits a data unit at one of a plurality of spreading factors over a data channel and transmits in parallel over a control channel a control unit comprising information for decoding said data unit,

the method comprising the steps of:

decoding an initial portion of the control unit;

decoding an initial portion of the data unit at an assumed one of said plurality of spreading factors; and

calculating the received power of the initial portions of the control unit and the data unit to make an estimate of the spreading factor used to transmit the data unit.

By estimating the correct spreading factor used to transmit the data unit based only an initial portion of the control unit and the data unit, the data unit can thereafter be properly decoded. Provision for the buffering of a whole data unit need not be made. It is also an advantage that, for the control channel, the transmission power need not be so high nor coding so powerful,

because said information for decoding the data unit is not the only indicator of the spreading factor used to transmit the data unit.

The data in the data unit and the control unit is preferably interleaved. The length of the data unit and the control unit corresponds to the interleaving interval. For example, when the data is interleaved over one system frame, the control unit and the data unit each occupy one system frame. Moreover, when data is interleaved over a number of frames, the control unit and the data unit occupy that number of frames. In this case, because the spreading factor is constant over an interleaving interval, when the second and subsequent frames of a data unit are transmitted their spreading factor is already known. In one embodiment, the said initial portion of the data unit can comprise one system frame.

Preferably, the lowest of the possible spreading factors is used to decode the initial portion of the data unit. By using this spreading factor, even if the data was actually transmitted with a higher spreading factor, the integrity of the data remains in tact even if it is poorly noise filtered.

According to another aspect, the present invention may provide a spread spectrum radio communication system, comprising a transmitter which transmits a data unit at one of a plurality of spreading factors over a data channel and transmits in parallel over a control channel a control unit comprising information for decoding said data unit, and a receiver comprising a decoder for decoding an initial portion of the control unit, a decoder for decoding an initial portion of the data unit at an assumed one of said plurality of spreading factors; and means for calculating the received power of the initial portions of the control unit and the data unit to make an estimate of the spreading factor used to transmit the data unit.

The present invention can be applied to especially, but not exclusively, to W_CDMA uplink.

In the context of the present invention, the term 'estimating the spreading factor' is used. It will be appreciated by those skilled in the art that by determining the spread factor (essentially a layer 1) quantity, the bit rate of data coming from layer is also, in effect, being determined, the bit rate being a straightforward and known function of the amount of repetition applied by the channel coding.

Exemplary embodiments of the invention are hereinafter described with reference to the accompanying drawings, in which:

Figure 1 shows a diagram of a cellular system useful for explaining the present invention;

Figure 2 shows a diagram of a mobile station transmitter architecture;

Figure 3 shows a diagram of a base station receiver architecture;

Figure 4 shows the frame structure of the DPCCH and DPDCH from an air interface perspective;

Figures 5(a-c) show the signal constellations for the receiver of Figure 3 with the DPDCH channel transmitting at three different power levels/spreading factors; and

Figure 6 shows the frames shown in Figure 4 from a user service perspective.

Referring back to Figure 1, in order for the base stations 10 to communicate with the mobile stations or radiotelephones 14, that is to set up, release and maintain connections therebetween, a number of functions need to be achieved over the air in both the uplink and the downlink These functions are carried out by means of logical channels.

Generically, the basic functions to be carried out are (i) *synchronisation*, where the mobile station locks onto the timing of a base station, enabling it to decode other channels; (ii) *broadcast*, where, for the purposes of initialisation, the mobile station decodes system and cell specific information e.g. cell identities, spreading codes, access channel and neighbouring cells lists; (iii) *random access*, where the mobile station can initiate a service request; (iv) *paging*, whereby an incoming service can be directed to the mobile station; (v) *dedicated channel control,* necessary for carrying signalling information such as handover measurements, service adaptation information, and power control information; (vi) *traffic*, necessary for carrying a wide variety of user-service data. Thus, generally logical channels exist corresponding to each of the functions (i) to (vi).

These basic functions can be mapped into physical channels, wherein the precise choice of how the logical channel are mapped into the physical channels will be highly system dependant.

In the system of the illustrated embodiment, the downlink comprises three common channels: a primary and a secondary common control physical channel (CCPCH), and a synchronisation channel (SCH) (function (i) above). The downlink also includes dedicated physical data channels (DPDCH) (function (vi) above) and physical control channel (DPCCH) (function (v) above). The primary CCPCH incorporates the point to multipoint broadcast control channel (BCCH) (function (ii) above). The secondary CCPCH

comprises a forward access channel (FACH) and a paging channel (PCH) (function (iv) above). The FACH is used for carrying control information to a mobile station when the network knows the location cell of the mobile station.

The uplink comprises one common channel, the random access channel (function (iii) above). The uplink also includes dedicated physical data channels (DPDCH) (function (vi) above) and physical control channel (DPCCH) (function (v) above).

When a mobile station, say 14a, is first powered up it initialises and registers with the network using the SCH to acquire synchronisation to the strongest base station, which in this case is 14a. Once synchronisation has occurred the mobile station 14a detects the CCPCH, reading the system and cell specific BCCH information. From the BCCH, the mobile station 14a acquires codes permitting it to make a call request with the network. After initialisation, the mobile station enters idle mode and waits to be paged by an incoming service, for example, by an incoming call, or for the user to request a service, for example place an outgoing call.

Services for the user are provided using the previously mentioned DPDCH and the DPCCH. Each of these physical channel consists of 10ms frames, each frame comprising 15 slots. In one mode, services are provided with the frames operating in a mode hereinafter referred to as the multirate mode. In this mode, the PDCH carries the user-service data at a data rate which is constant within a single frame, but may vary from frame to frame. The DPCCH carries control information necessary to decode the DPDCH. Specifically, each frame of the DPCCH includes a transport format indication TFI which carries information indicating the data rate of the corresponding frame of the DPDCH. The DPCCH also carries power control symbols, pilot

symbols and service parameter information for the corresponding frame of the DPDCH.. The DPCCH is transmitted at constant data rate.

Figure 2 shows the transmitter 30 architecture of a mobile station for transmitting data on these two physical channels. The base station comprises a DPDCH baseband processor 32 for baseband processing data for transmission on the DPDCH, and a DPCCH baseband processor 34 for baseband processing data for transmission on the DPCCH. Each baseband processor 32, 34 is operable to provide the conventional baseband processing operations, including, for example, convolution coding, turbo coding, puncturing/repetition and interleaving.

The data from each baseband processor 32, 34 is fed to a spreading modulation element 36. Within the spreading modulation element 36, the data for the DPDCH is spread by PN code Cd in a spreading element 38 and scaled by a factor Ad in scaling element 40 to give a signal I, and the data for DPDCH is spread by PN code Cc in spreading element 42 and scaled in scaling unit 44 by a factor Ac to give a signal Q. The codes Cd and Cc are orthogonal variable spreading factor codes. The signals I, Q are then fed to a quadrature modulator (QPSK) 46 to produce a signal I + jQ. This signal is then spread again by a PN scrambling code Cscramb in spreading element 48 which is a complex user-specific scrambling code to give signal R. The codes Cd and Cc are for channelisation.

The multiplexed and spread signal R is then upconverted to the frequency F, power amplified and transmitted by RF section 50.

Figure 3 shows the receiver 60 architecture for the receiver of the base station.

The receiver 60 comprises an RF section 80 for demodulating the received signals into the I,Q parts. A power estimator unit provides an estimate of the power of I and Q and feeds this information to a baseband processing unit 65. As described below in more detail below, the baseband processing unit of the receiver 60 is able to use the power estimates I and Q to calculate an estimate of the spreading factor/data rate.

The frame structure of the multirate mode is illustrated in Figure 4. 5 exemplary 10ms frames are shown, the DPCCH frames are labelled 101 to 105, and the corresponding DPDCH frames are labelled 201 to 205.

If Figure 4 is considered as a simple example of a uplink transmission, from the air interface (layer 1) perspective, the user data stream is transmitted on DPDCH as three data units. Data unit 1 is transmitted over frames 1 and 2 at the highest power, P1 (and hence lowest spreading factor); data unit 2 is transmitted over frames 3 and 4 at a lesser power, P2; and data unit 3 is transmitted over frame 5 only at the lowest power, P3 (and hence highest spreading factor). The data rate of the blocks is changed by changing the length of the spreading codes or using parallel spreading codes in the spreading modulation unit 36 or by puncturing/repetition in the DPDCH baseband processor 32. Because of the interleaving operation in the baseband processor 32, the user service data is interleaved over both frames 1 and 2 in block 1, over both frames 3 and 4 in block 2, and over only frame 5 in block 3. Similarly, the data stream in the DPCCH, notably the FCH, is interleaved over frames 1 and 2, frames 3 and 4, and frame 5, corresponding to the data units in the DPCCH. As explained above though, the transmission power on this channel is constant, P0.

The receiver 60 knows *a priori* the set of possible ratios of data channel receive power to control channel receive power. Expressed in other words, it

may be thought that the receiver 60 knows the set of absolute transmission powers/spreading factors, because the channel attenuation of the data channel and the control channel is approximately the same, the corresponding received powers are related to the corresponding transmission power by the same factor of proportionality. Hence, the set of possib' ratios of data channel power to control channel power as transmitted are the same as the set possible of possible powers on reception.

Thus, in this way, the transmission power and hence the spreading factor can be estimated in principle. Figure 5(a-c) shows the signal constellations for received power is P3', P2' and P1', respectively. It will be appreciated that because the control and data channels are subjected to varying degrees of attenuation, the magnitude of the signal constellations vectors varies, but because the attenuation is approximately the same, their angles remain the same.

Referring again to Figure 4, in order to estimate the relationship between the received power of the control channel and the data channel before the spreading factor used to transmit the data channel can be decoded from the control channel DPCCH, the data channel DPCDH signal is decoded assuming the lowest of the set of allowed spreading factors. With this assumption, the samples from the first 20 % or so of frame 1 of the data channel DPCDH are decoded and averaged to give a power estimate Pda. Over the same interval, the control channel DPCCH is also decoded at its known, fixed spreading factor. The samples decoded from each channel are squared and averaged to give an estimate Pca. The ratio Pda/Pca will correspond more closely to one of P3'/P0', P2'/P0' or P1'/P0' and hence yield an estimate of the corresponding spreading factor. Once an estimate of the spreading factor is so obtained, decoding of the data channel begins at the estimated spreading factor and hence little buffering is needed. In this way,

both frames 1 and 2 are decoded. The process is then repeated for data unit 2, and subsequently for data unit 3.

It will be appreciated that as the number of frames in a data unit increases the advantage of not having to buffer the whole data unit to properly to decode the TFI becomes more and more significant.

Because communication between the base station 10a and the mobile station 14a takes place over a multirate data channel DPDCH having a corresponding control channel DPCCH which is transmitted in parallel and carries information about the data on the data channel, this channel architecture can be exploited advantageously in accordance with the described preferred embodiment of the invention to flexibly bundle a variety of user services into the data channel according to the priority of the services and the current data rate supportable by the data channel. For example, if there are four sets of user service data which need to be transmitted, say services 1 to 4 and, for convenience of explanation, the priority of the services is also in numerical order (whereby service 1 is the highest priority and service 4 is the lowest priority), then these services could be transmitted in accordance with the preferred embodiment of the invention as shown in Figure 6. In Figure 6, the same data units 1 to 3 of Figure 4 are considered from a user services perspective. In data unit 1, transmitted with the power P1, where the spreading factor is the lowest and hence the data rate the highest, all services 1 to 4 are being transmitted.. In data unit 2, which is at a lower power P1 and lower data rate, only higher priority services 1 and 2 are transmitted. In data unit 3, which is at the lowest power P2 and lowest data rate (highest spreading factor), only the highest priority service 1 is transmitted. Although for diagrammatic simplicity the services are shown in consecutive, separate time segments, in practice, each service is evenly interleaved over the respective data unit.

In other embodiments, the whole data unit can be decoded before estimation of the data rate/ spreading factor because this may lead to better estimation.

CLAIMS

1. A method of estimating the spreading factor of data in a channel in a spread spectrum radio communication system comprising a transmitter and a receiver, wherein the transmitter transmits a data unit at one of a plurality of spreading factors over a data channel and transmits in parallel over a control channel a control unit comprising information for decoding said data unit,

the method comprising the steps of:

decoding an initial portion of the control unit;

decoding an initial portion of the data unit at an assumed one of said plurality of spreading factors; and

calculating the received power of the initial portions of the control unit and the data unit to make an estimate of the spreading factor used to transmit the data unit.

2. A method as in Claim 1, wherein data in the control unit and the data unit is interleaved over the duration of the respective units.

3. A method as in Claim 2, wherein the data unit comprises a single frame.

4. A method as in Claim 2, wherein the data unit comprises a plurality of frames.

5. A method as in any preceding claim, wherein the assumed spreading factor is the lowest of said plurality of spreading factors.

6. A method as in any preceding claim, wherein said estimate is calculated by matching the relationship between the received powers of the control unit and the data unit with a member of a set of possible power relationships known *a priori*, wherein each member of the set corresponds to one of said spreading factors.

7. A method as in any preceding claim, wherein, after having made said estimate, the rest of the data unit is decoded using the said estimate of the spreading code.

8. A method as in any preceding claim, wherein a said data unit comprises data relating to a plurality of user services.

9. A method of estimating the spreading factor of data in a channel in a spread spectrum radio communication system comprising a transmitter and a receiver, wherein the transmitter transmits a data unit at one of a plurality of spreading factors over a data channel and transmits in parallel over a control channel a control unit comprising information for decoding said data unit,

the method comprising the steps of:

decoding an initial portion of the control unit;

decoding the whole of the data unit at an assumed one of said plurality of spreading factors; and

calculating the received power of the initial portions of the control unit and the data unit to make an estimate of the spreading factor used to transmit the data unit.

10. A spread spectrum radio communication system, comprising :

a transmitter which transmits a data unit at one of a plurality of spreading factors over a data channel and transmits in parallel over a control channel a control unit comprising information for decoding said data unit, and

a receiver comprising a decoder for decoding an initial portion of the control unit, a decoder for decoding an initial portion of the data unit at an assumed one of said plurality of spreading factors; and means for calculating the received power of the initial portions of the control unit and the data unit to make an estimate of the spreading factor used to transmit the data unit.

11. A mobile station including a receiver as defined in Claim 8.

12. A method of estimating the spreading factor of data in a channel in a spread spectrum radio communication system substantially as hereindescribed with reference to the accompanying drawings.

13. A spread spectrum radio communication system constructed, arranged and adapted to operate substantially as hereindescribed with reference to the accompanying drawings.

14. A mobile station for a spread spectrum communication system constructed, arranged and adapted to operate substantially as hereindescribed with reference to the accompanying drawings.

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Published:
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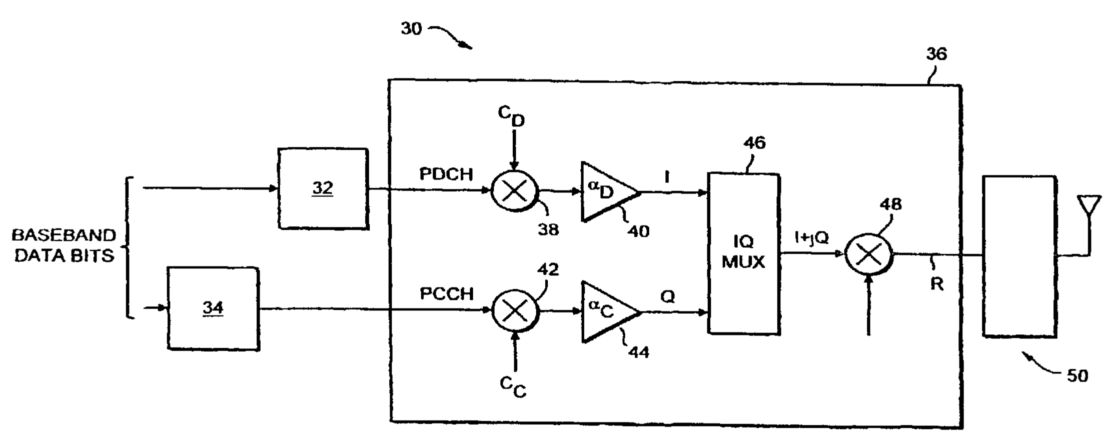
For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: SPREAD SPECTRUM COMMUNICATION SYSTEM



(57) Abstract: This invention is concerned with the situation where communication between a base station and a mobile station take place over a multirate data channel having a corresponding control channel which is (i) transmitted in parallel with the data channel and which (ii) needs to be adequately decoded to extract control information in order to properly decode the data channel. The invention provides a method of and a system for estimating the spreading factor of data in a channel in a spread spectrum radio communication system comprising a transmitter and a receiver, wherein the transmitter transmits a data unit at one of a plurality of spreading factors over a data channel and transmits in parallel over a control channel a control unit comprising information for decoding said data unit, the method comprising the steps of: decoding an initial portion of the control unit; decoding an initial portion of the data unit at an assumed one of said plurality of spreading factors; and calculating the received power of the initial portions of the control unit and the data unit to make an estimate of the spreading factor used to transmit the data unit.

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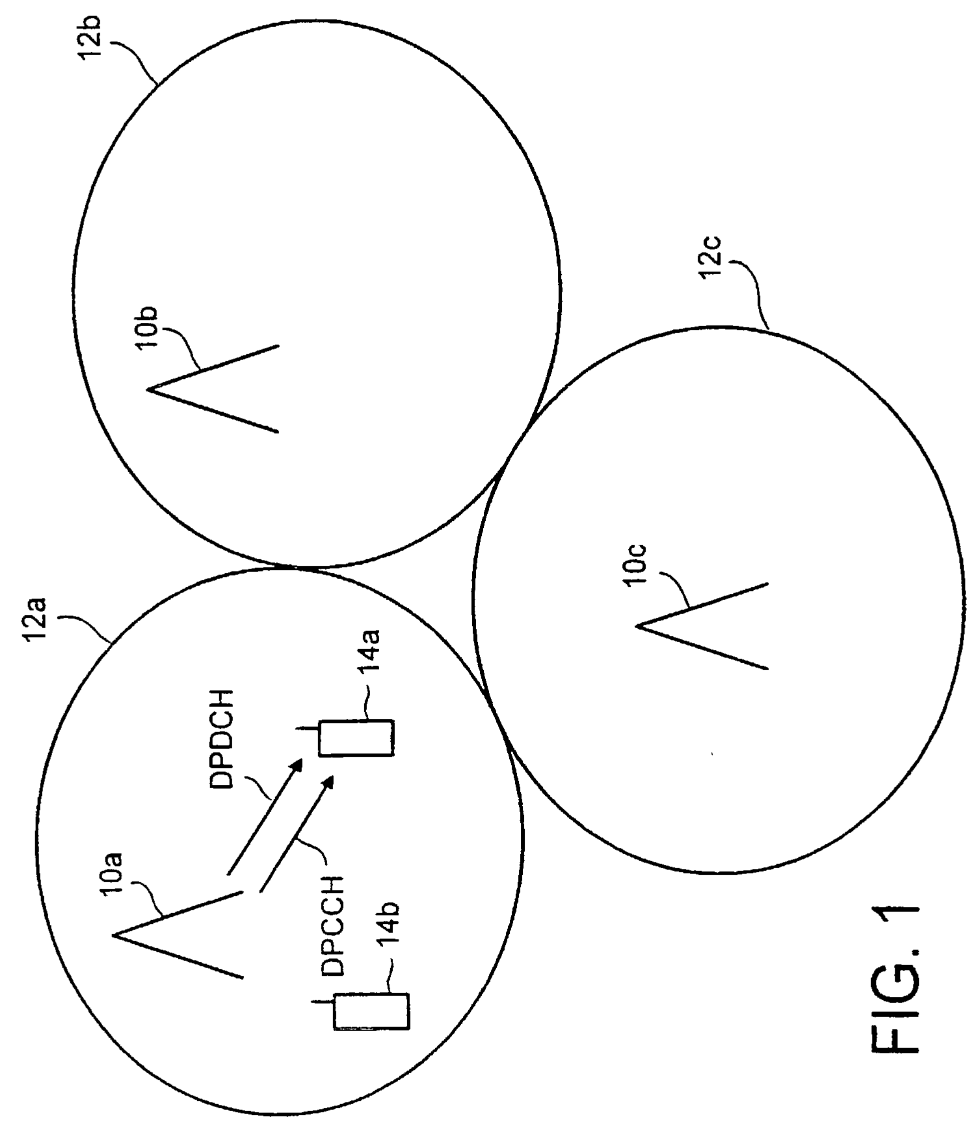
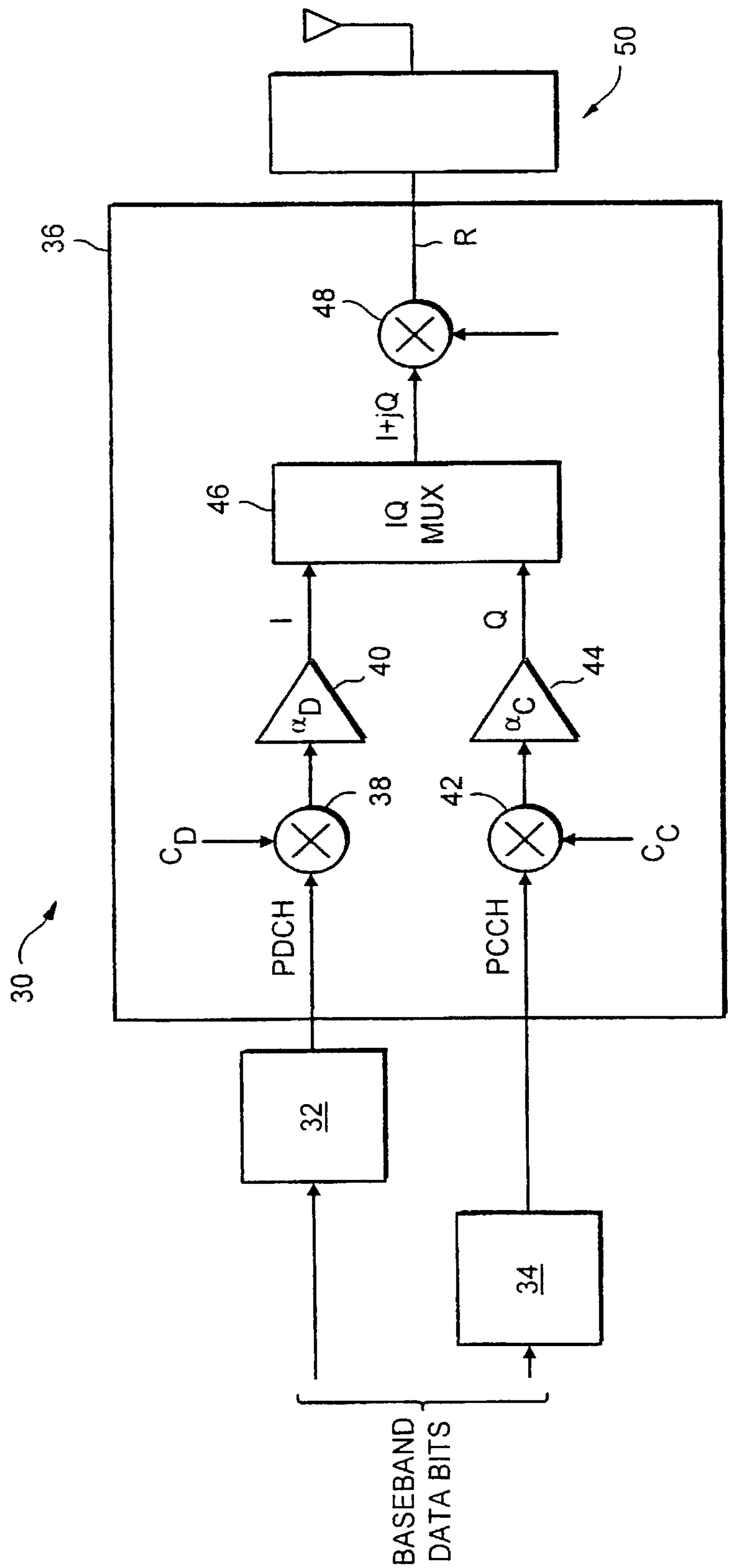


FIG. 1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36
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48
I+jQ
46
IQ
MUX
I
Q
40
44
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α_C
38
42
C_D
C_C
PDCH
PCCH
30
32
34
BASEBAND
DATA BITS

FIG. 2

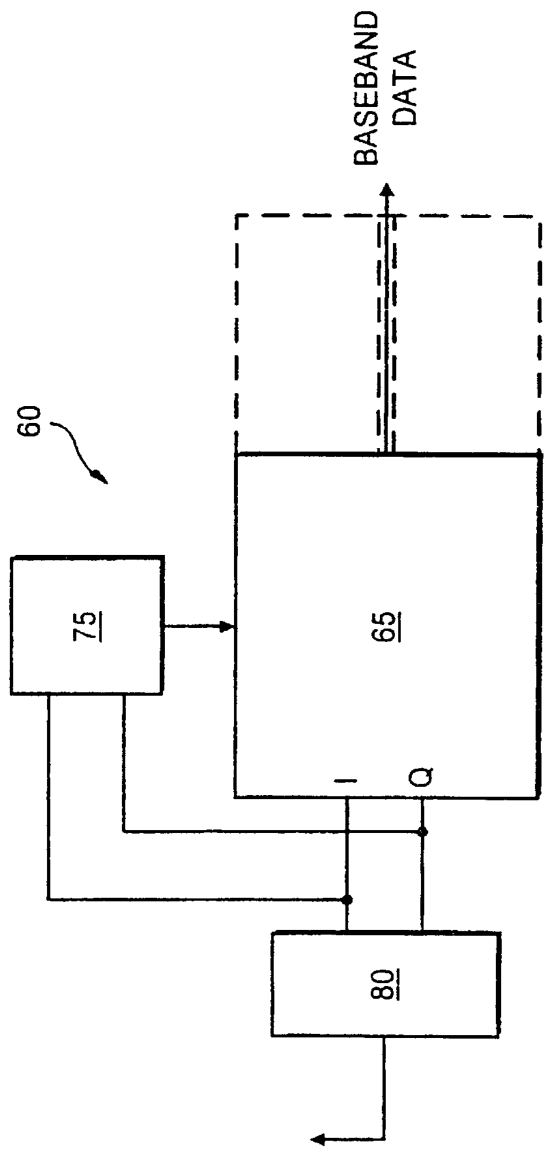
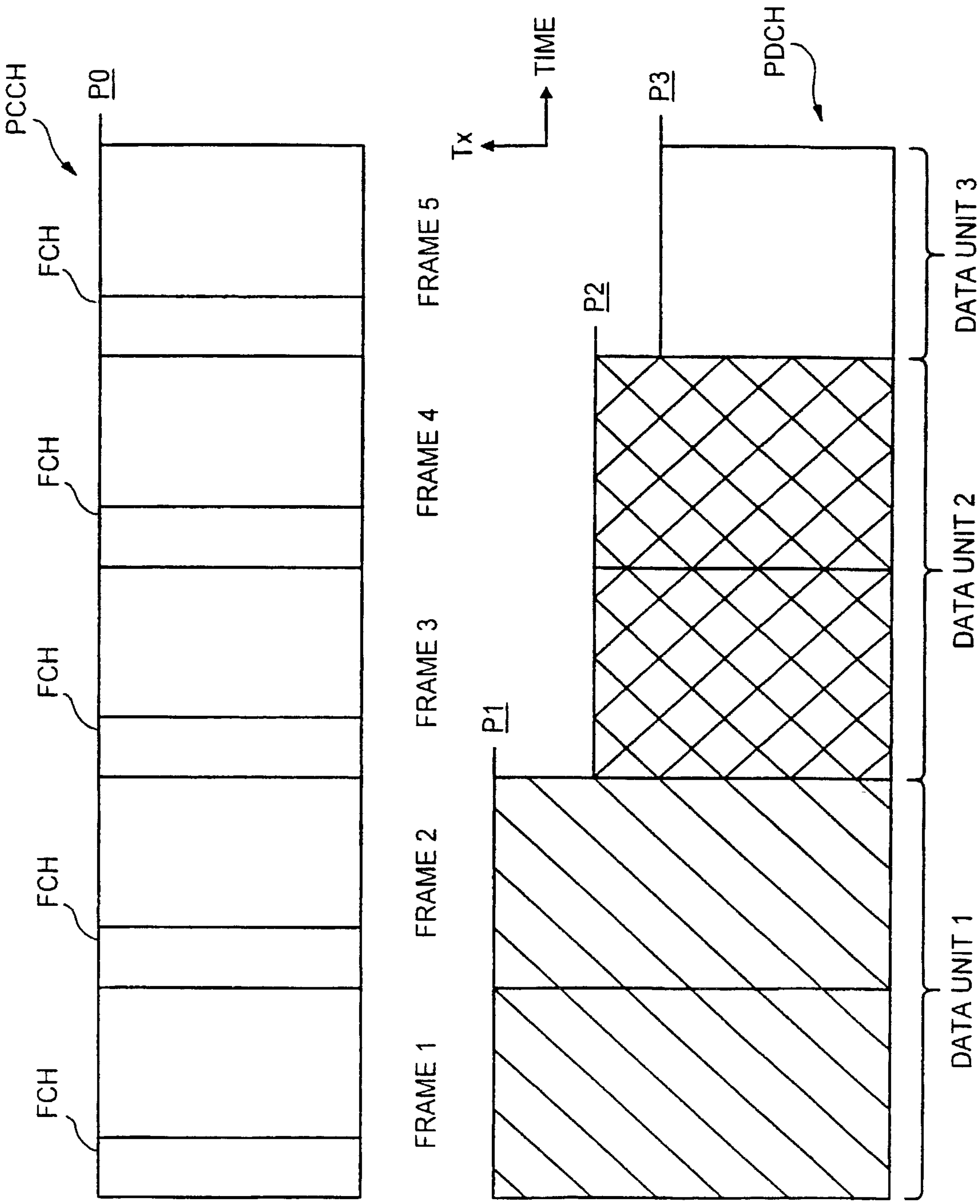


FIG. 3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P0
FCH
FCH
FCH
FCH
FCH
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FRAME 4
FRAME 3
FRAME 2
FRAME 1
TIME
Tx
PDCH
P3
P2
P1
DATA UNIT 3
DATA UNIT 2
DATA UNIT 1

FIG. 4

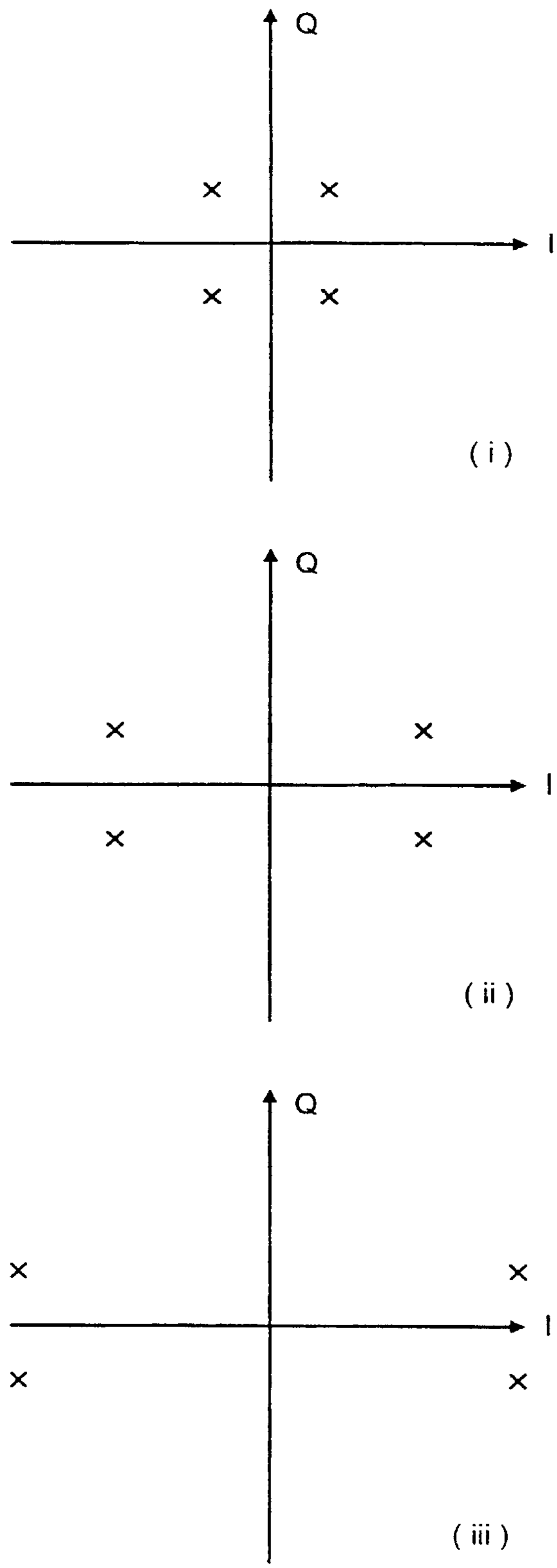
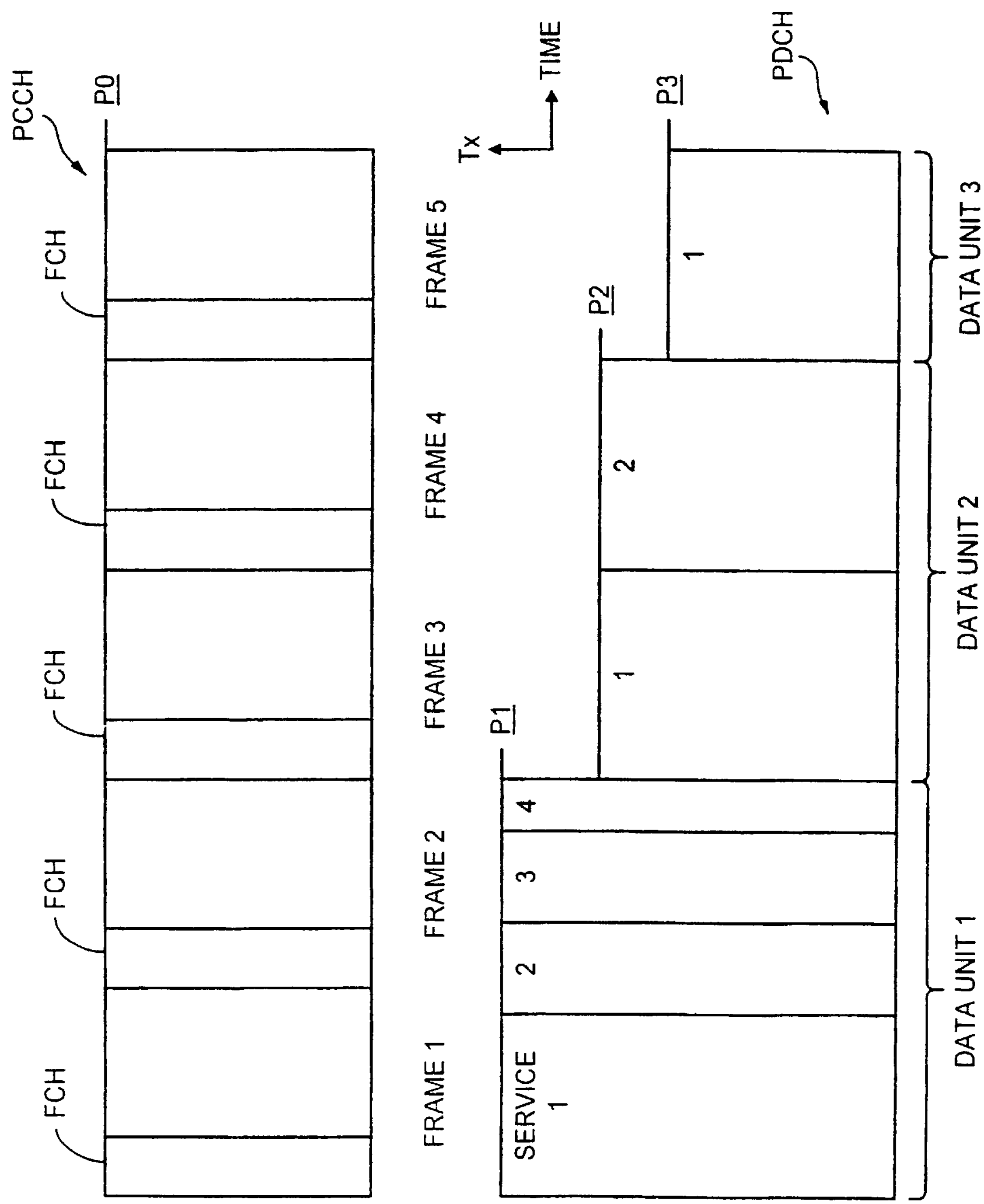


FIG. 5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FRAME 2
FRAME 3
FRAME 4
FRAME 5
Tx
TIME
PDCH
P1
P2
P3
SERVICE 1
2
3
4
1
2
1
DATA UNIT 1
DATA UNIT 2
DATA UNIT 3

FIG. 6

Attorney's Docket No. 367.41482X00 :

DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

As a below named inventor, I hereby declare that: my residence, post office address and country of citizenship are as stated below, next to my name; I believe I am the original, first, and sole inventor (if only one name is listed below) or an original, first, and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

SPREAD SPECTRUM COMMUNICATION SYSTEM

the specification of which

___ is attached hereto.

X was filed on 27th March 2002 as
United States Application Number 10/089145
or PCT International Application Number PCT/IB99/01668
and was amended on ______.
(if applicable)

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claim(s), as amended by any amendment referred to above. I acknowledge the duty to disclose all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits, under 35 U.S.C. 119(a)-(d) or 365(b), of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor=s certificate, or any PCT international application having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)

			Priority Claimed?	
(Number)	(Country)	(Foreign Filing Date)	Yes	No
(Number)	(Country)	(Foreign Filing Date)	Yes	No

I hereby claim the benefit, under 35 U.S.C. 119(e), of any United States provisional application(s) listed below:

(Application Number)	Filing Date
(Application Number)	Filing Date

I hereby claim the benefit, under 35 U.S.C. 120, of any United States application(s) listed below:

(Application Number)	Filing Date	(Status -- patented, pending, abandoned)
(Application Number)	Filing Date	(Status -- patented, pending, abandoned)

I hereby appoint: Donald R. Antonelli, Reg. No. 20,296; Melvin Kraus, Reg. No. 22,466; William I. Solomon, Reg. No. 28,565; Gregory E. Montone, Reg. No. 28,141; Ronald J. Shore, Reg. No. 28,577; Donald E. Stout, Reg. No. 26,422; Alan E. Schiavelli, Reg. No. 32,087; James N. Dresser, Reg. No. 22,973; Carl I. Brundidge, Reg. No. 29,621; Paul J. Skwierawski, Reg. No. 32,173; and Robert M. Bauer, Reg. No. 34,487; of ANTONELLI, TERRY, STOUT & KRAUS, LLP with offices located at 1300 North Seventeenth Street, Suite 1800, Arlington, Virginia 22209, my attorneys, with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected herewith.

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FAX: (703) 312-6666

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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Inventor's Signature Harri Holma Date 12.6.2002
Residence Itatuulelkuji, 1 D 32, FIN-02100, Espoo, Finland Citizenship Finnish
(City, State) (Country of Citizenship)
Mailing Address As above

Full Name of Second/Joint Inventor ____

Inventor's Signature ____ Date ____
Residence ____ Citizenship ____
(City, State) (Country of Citizenship)
Mailing Address ____

Full Name of Third/Joint Inventor ____

Inventor's Signature ____ Date ____

Residence ____ Citizenship ____
(City, State) (Country of Citizenship)
Mailing Address ____

Title 37, Code of Federal Regulations, Section 1.56
<u>Duty to Disclose Information Material to Patentability</u>

(a) A patent by its very nature is affected with a public interest. The public interest is best served, and the most effective patent examination occurs when, at the time an application is being examined, the Office is aware of and evaluates the teachings of all information material to patentability. Each individual associated with the filing and prosecution of a patent application has a duty of candor and good faith in dealing with the Office, which includes a duty to disclose to the Office all information known to that individual to be material to patentability as defined in this section. The duty to disclosure information exists with respect to each pending claim until the claim is cancelled or withdrawn from consideration, or the application becomes abandoned. Information material to the patentability of a claim that is cancelled or withdrawn from consideration need not be submitted if the information is not material to the patentability of any claim remaining under consideration in the application. There is no duty to submit information which is not material to the patentability of any existing claim. The duty to disclosure all information known to be material to patentability is deemed to be satisfied if all information known to be material to patentability of any claim issued in a patent was cited by the Office or submitted to the Office in the manner prescribed by 991.97(b)-(d) and 1.98. However, no patent will be granted on an application in connection with which fraud on the Office was practiced or attempted or the duty of disclosure was violated through bad faith or intentional misconduct. The Office encourages applicants to carefully examine:

(1) Prior art cited in search reports of a foreign patent office in a counterpart application, and

(2) The closest information over which individuals associated with the filing or prosecution of a patent application believe any pending claim patentably defines, to make sure that any material information contained therein is disclosed to the Office.

(b) Under this section, information is material to patentability when it is not cumulative to information already of record or being made or record in the application, and

(1) It establishes, by itself or in combination with other information, a prima facie case of unpatentability of a claim; or

(2) It refutes, or is inconsistent with, a position the applicant takes in:

(i) Opposing an argument of unpatentability relied on by the Office, or

(ii) Asserting an argument of patentability.

A prima facie case of unpatentability is established when the information compels a conclusion that a claim is unpatentable under the preponderance of evidence, burden-of-proof standard, giving each term in the claim its broadest reasonable construction consistent with the specification, and before any consideration is given to evidence which may be submitted in an attempt to establish a contrary conclusion of patentability.

(c) Individuals associated with the filing or prosecution of a patent application within the meaning of this section are:

(1) Each inventor named in the application;

(2) Each attorney or agent who prepares or prosecutes the application; and

(3) Every other person who is substantively involved in the preparation or prosecution of the application and who is associated with the inventor, with the assignee or with anyone to whom there is an obligation to assign the application.

(d) Individuals other than the attorney, agent or inventor may comply with this section by disclosing information to the attorney, agent, or inventor.

(e) In any continuation-in-part application, the duty under this section includes the duty to disclose to the Office all information known to the person to be material to patentability, as defined in paragraph (b) of this section, which became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application.